



ORIGINAL ARTICLE

A Novel Construct To Measure Employees' Technology-Related Experiences of Well-Being: Empirical Validation of the Techno-Work Engagement Scale (TechnoWES)

Jaana-Piia Mäkineniemi, Salla Ahola and Johanna Joensuu

Because of the current developments in digitalization, novel technological solutions have changed work processes and accordingly influenced employee well-being. There is a lack of measures of positive well-being experiences regarding technology at work. Therefore, the current study introduces a novel construct—namely techno-work engagement—and a scale to measure it. Techno-work engagement is defined as a positive experience of well-being regarding the use of technology at work. The study tested the factorial, discriminant, and convergent validity of the scale, TechnoWES-9. Using data from two samples, the factor structure of the construct was analyzed with a confirmatory factor analysis (CFA). In addition, in Study 2, CFAs, correlations, and mean differences were used to assess the discriminant and convergent validity and whether the shorter scale can be used as an alternative to the longer one. The results concerning the factorial validity support the view that techno-work engagement is better represented as a three-factor than as a unidimensional construct. Like TechnoWES-9, TechnoWES-3 is positively correlated with technology-related job resources; also, both can be discriminated from technostress. TechnoWES-9, although not flawless, is a reliable and valid indicator of techno-work engagement, and the shorter version can be used as its alternative. In the future, the relationships between work engagement, technostress, and techno-work engagement could be measured and the scale could be tested in different countries and occupations.

Keywords: work engagement; technology; techno-work engagement; technostress; confirmatory factor analysis; validation

Introduction

Digitalization of working life

Beginning in the 1960s, divergent microelectronics and robotics technologies were introduced in manufacturing, increasing the level of automation (Stock et al., 2018). The computerization of work began in 1970, and now, about 52% of European employees work with computers at least 25% of their work time (Korunka and Hoonaker, 2014; Korunka and Vartiainen, 2017). It is commonly suggested we are now in the middle of the Fourth Industrial Revolution, and work processes will change dramatically because of novel technological breakthroughs, such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, biotechnology, and quantum computing (Schwab, 2015); in addition, big data analytics and cloud technology will be one of the key drivers of business growth (World Economic Forum, 2018). For example, in the future, nurses will work in collaboration with medical robots, 3D printers will become part of manufacturing processes, and at least some face-to-face interactions will be replaced by chatbots.

Evidently, there appear to be pitfalls related to the development of digitalization, such as the possible displacement of employees. Being a type of control, novel digital measuring systems for tracking performance and productivity may also cause concerns among employees (Rolandsson et al., 2019). However, current developments have also positive effects, such as safer and more rewarding jobs if different technologies take care of the demanding, monotonous, and dangerous tasks. For example, industrial robots can assist workers with heavy objects (Fischer and Pöhler, 2018). To control the ongoing revolution, we need a comprehensive view of how (digital) technology affects our lives (Schwab, 2015). Thus, there is a need for a balanced picture of both the negative and positive effects of intensive digitalization of work on employee well-being. The aim of the current paper is to present a new concept called *techno-work engagement* and to validate a novel scale for measuring it with two different studies.

Techno-work engagement as a positive and fulfilling well-being experience

Techno-work engagement is based on the concept of work engagement, which is a positive and fulfilling work-related state of mind; this can be further divided into three dimensions: vigor, dedication, and absorption (Schaufeli

et al., 2002). Vigor refers to high levels of energy, mental resilience, and a willingness to put in effort and to be persistent. Dedication is characterized by enthusiasm, inspiration, and pride, while absorption involves full concentration on one's work (Schaufeli et al., 2002). Work engagement describes how employees feel in relation to their work in general; whereas, techno-work engagement is a more specific state of work well-being in relation to the use of (digital) technology at work (c.f. Mäkiniemi, Ahola and Joensuu, 2019). Therefore, techno-work engagement can be defined as follows: *Techno-work engagement is a positive and fulfilling well-being state or experience that is characterized by vigor, dedication, and absorption with respect to the use of technology at work.*

Work engagement was selected as a base because it is a well-known, established, and validated concept (for a review, see Kulikowski, 2017). The levels of work engagement can vary within people from day to day and when they work on different work tasks (for a review, see Sonnentag, 2017). In line with the task-specific approach (e.g., Sonnentag, 2017), we focus on employees' work engagement experiences as they work on work tasks that involve technology. Other specific scales have also been developed, such as the Schoolwork Engagement Inventory (EDA) (Salmela-Aro and Upadaya, 2012). We assume techno-work engagement is a specific type of work engagement.

In prior studies on technology-related work well-being experiences, the focus has been mostly on employees' negative experiences with technology, namely technostress experiences. Technostress refers to a specific type of work stress experienced by end users because of their use of information and communication technologies (ICT) at work (Salanova, Llorens and Cifre, 2013). Typical technostress experiences include four types of feelings: anxiety, fatigue, skepticism, and beliefs concerning inefficacy related to the use of technologies (Salanova et al., 2013; Salanova, Llorens and Ventura, 2014). Thus, technostress can be defined as a negative well-being experience or state; whereas, techno-work engagement is a positive one. Accordingly, we expect technostress is a divergent concept from techno-work engagement.

Relations with techno-work engagement and technology-related job resources

Several studies have found a positive association between job resources and work engagement (Bakker, Albrecht and Leiter, 2011; Halbesleben, 2010). Typical job resources include social support, variability, appreciation, feedback, and autonomy, all of which stimulate personal growth, learning and development, assist in achieving the goals of the job, and buffer the negative effects of demands (Bakker and Demerouti, 2007). Because we assume techno-work engagement is a specific type of work engagement, we also expect there will be a positive association between technology-related job resources and techno-work engagement. Therefore, technology-related job resources may enhance or support techno-work engagement. This is in line with the theoretical framework developed by Day, Scott, and Kelloway (2010): employees can experience the use of technology related to working life—such as

ICT—either as a job demand or job resource. Simply put, when technology acts as a job resource, it assists with the completion of work goals and promotes learning and development. For example, a teacher who uses education technology may use technology to improve the quality of students' learning, which is the teacher's work goal; it also gives the teacher an opportunity to learn new things and supports professional development. The use of ICT at work can assist in effective information transfer, improve work performance, and give more freedom and flexibility to employees in terms of working places and work-life balance, thus enhancing employee well-being (Bordi et al., 2018; Day et al., 2010). In addition, ICT at work can enhance productivity, help to provide better service quality (Korunka and Hoonaker, 2014; Korunka and Vartiainen, 2017), and assist human decisions with complex data analysis (Fischer and Pöhler, 2018).

In the current study, we examined the relation between techno-work engagement and four technology-related job resources, namely technology-related autonomy (Lam, Cheng and Choy, 2010; Mäkiniemi et al., 2019), technology-related social/collegial support (Lam et al., 2010; Mäkiniemi et al., 2019), technology-related self-efficacy (Wang, Ertmer and Newby, 2004; Mäkiniemi et al., 2019), and technology-related value congruence (Skaalvik and Skaalvik, 2011). All the above-mentioned resources, when measured as general job resources, are shown to be positively associated with general work engagement (e.g., Bakker and Demerouti, 2007; Huhtala and Feldt, 2016; Li et al., 2015; Nielsen et al., 2017; Schaufeli and Bakker, 2004; Sortheix et al., 2013; Ventura, Salanova and Llorens, 2015; Xanthopoulou et al., 2007). Accordingly, we assume technology-related job resources are positively related to techno-work engagement.

On the other hand, when technology acts as a job demand, it requires sustained and extended physical or psychological effort or skills, and it might be associated with increased physical and psychological costs, such as exhaustion or stress. For example, typical ICT-related demands include ICT malfunctions, incompatible technologies, expectations of continuous learning, fast responses and constant availability, information overload, and poor quality of communication (Day et al., 2010; Stich et al., 2015). Usually, learning new technologies requires extra time and effort, potentially causing stress (c.f. Ragu-Nathan et al., 2008). Likely, technology-related job demands also can be further divided as challenge (e.g., learning new things) or hindrance demands, as is the case with general job demands (c.f. Tadić, Bakker and Oerlemans, 2015). Technology-related job demands share a lot of similarities with techno-stressors, which create or are the source of technostress. Typical techno-stressors include forced changes related to work habits, the complexity of technology, fear of being replaced, and constant technological change (Ragu-Nathan et al., 2008). Employees might also have feelings and thoughts concerning work-related technologies without prior experience of the technologies. For example, employees can feel insecure because of the current trend toward the automation and digitalization of work. In addition,

technological changes, including the adoption of new technologies, may influence the work system and the psychosocial work environment, including job control and social relations (Carayon and Smith, 2014; O'Driscoll, Biron and Cooper, 2009).

Need for a novel scale for measuring positive well-being experiences with respect to the use of technology at work

Taken together, based on prior studies, it is well-known what kinds of factors are considered demanding (e.g., information overload as a technology-related job demand) and inspiring (e.g., flexibility as a technology-related job resource) when using technology at work. Prior studies have focused largely on techno-stressors (i.e., technology-related job demands) without analyzing their relation to any negative or positive well-being states. Especially, little is known about employees' positive experiences or states of well-being regarding the use of technology. We assume this to stem partly from the fact there is a lack of measurement instruments to assess these kinds of positive experiences of well-being.

We argue there are four main reasons why a new construct and scale is needed. First, digitalization of work and work processes will continue to advance (e.g., Schwab, 2015), so there is a need to obtain a comprehensive picture of its effects on employee well-being. Second, as stated earlier, most prior studies on employee well-being and technology use at work have focused on negative well-being experiences and techno-stressors (Day et al., 2010; Day et al., 2012; Ragu-Nathan et al., 2008; Stich et al., 2015). This scope might be too narrow when considering that one aim of work digitalization is to increase employee well-being, for instance, by reducing the physical demands of work. With the negatively loaded items, it is not possible to capture the positive aspects of the phenomenon because the lack of a negative experience (e.g., low level of technostress) does not necessarily indicate the presence of a positive experience (e.g., high techno-work engagement). Also, leading technostress researchers have pointed out a need for a more positive approach and concepts such as good technostress, or eustress, when using technology at work (Tarafdar, Cooper and Stich, 2019). Techno-work engagement is a potential candidate for measuring these kinds of positive well-being experiences. Third, technology has been often limited to ICT, and the focus of these studies has been on the effects of computer-mediated work on employee well-being (for a review, see Stich et al., 2015). The prior scope might be too limited when considering the new types of technologies being introduced to employees, such as robots, chatbots, 3D printers, and virtual reality. Therefore, there is a need for a measurement scale that is not limited to a specific technology (e.g., a computer) but that can be adjusted to different contexts and technologies. Fourth, we believe with the novel scale it will not only be possible to explore and understand the levels of techno-work engagement, but also to understand which factors (e.g., technology-related job resources) are associated with it; it will also be possible to develop employee well-being in the context

of digitalized work rather than just trying to eliminate the demanding aspects. Thus, with a valid short scale, organizations can track the effects of digitalization of work processes in a more comprehensive way.

Therefore, the main aim of the current study is to assess the factorial validity of the novel Techno-Work Engagement Scale (TechnoWES) in two studies and to explore which factorial structure is more valid. Based on the work engagement theory and empirical findings, we hypothesize a three-factor structure will be superior to a one-factor structure (H1) (Bakker et al., 2011). Further, because work engagement can be reliably measured with an ultrashort three-item scale (Schaufeli et al., 2017), we assume a three-item version of the TechnoWES is a valid indicator of techno-work engagement along with the longer nine-item version. We analyze this possibility in Study 2 and simultaneously assess the convergent and discriminant validity of both versions of the TechnoWES. Moreover, we assess the discriminant validity by testing whether the TechnoWES is a unique scale differing from the technostress scale (Salanova et al., 2013). We hypothesize that because technostress is a negative well-being experience and techno-work engagement is a positive one (Mäkineniemi et al., 2019; Salanova et al., 2013), techno-work engagement can be discriminated from technostress and there will be a weak or moderate negative correlation between the constructs for both versions of the TechnoWES (H2).

Moreover, in line with the assumption techno-work engagement might be a specific type of work engagement and with previous studies suggesting a positive association between job resources and work engagement (e.g., Nielsen et al., 2017; Schaufeli et al., 2017), we assume technology-related autonomy, technology-related social support, technology-related self-efficacy, and technology-related value congruence are positively associated with techno-work engagement at a weak or moderate level (c.f. Schaufeli et al., 2017), and this applies for both versions of the TechnoWES (H3). In line with the findings on the three-item scale of work engagement (Schaufeli et al., 2017), we expect the three-item and nine-item versions of TechnoWES are highly correlated (H4). Observing these correlations would also support the convergent validity of the TechnoWES. Finally, in line with the previous findings suggesting demographic differences on work engagement (e.g., Hakanen et al., 2019) and on technostress (e.g., Syvänen et al., 2016), we explore whether there are differences in the mean score of techno-work engagement and whether the relationships of demographics with the TechnoWES are similar when measured with the three-item and the nine-item scale.

Summary of the hypotheses for Study 1 and Study 2

H1: A three-factor structure of TechnoWES will be superior to a one-factor structure of it (Study 1; Study 2).

H2: Techno-work engagement can be discriminated from technostress, and there will be a weak or moderate negative correlation between the constructs for both versions of the TechnoWES (Study 2).

H3: Technology-related autonomy, technology-related social support, technology-related self-efficacy, and technology-related value congruence are positively associated with techno-work engagement at a weak or moderate level, and this applies for both versions of the TechnoWES (Study 2).

H4: The three-item and nine-item versions of TechnoWES are highly correlated (Study 2).

Study 1

Method

Participants and data collection

Originally, 830 Finnish employees from eight public and private organizations participated. A total of 5,136 employees were contacted, either by sending an invitation to participate and a link to the electronic questionnaire directly to each employee's email address or by informing the employees about the study via the organization's intranet (or otherwise within the organization), depending on the organization's policies. All the procedures followed ethical principles and the codes of conduct of the American Psychological Association. Informed consent was obtained from the participants. Altogether, 16% completed the questionnaire, with the response rates varying from 4–87% across the organizations. Based on the data screening prior to analysis, 101 respondents had not discriminated between their answers on the Techno-Work Engagement Scale (TechnoWES) but had used the same response option for all nine items. Of them, 21.8% had chosen the lowest extreme option of the scale for all nine items, and 24.8% had chosen the highest extreme option. Not discriminating between answers was considered an indication of possible response bias, which refers to a systematic tendency to respond to a range of items on a basis other than the specific item's content. Particularly within validation studies, such response bias may affect the validity of the results; therefore, we took this into account. The analyses were conducted without these respondents' data, resulting in a total number of 729 respondents, of whom 495 (67.9%) were female, 213 (29.2%) were male, and 21 (2.9%) chose not to indicate their gender. The average age of the respondents was 45.9 ($SD = 10.8$; range 17–67) years. The respondents were highly educated, with 45.5% having completed university education and 23.3% having completed a university of applied sciences education. A total of 22.5% of the respondents had completed vocational education, 7.1% had general upper secondary education, and 1.5% had basic education. The majority (55.3%) were officials or experts, 21.4% were workers, 16.9% were supervisors or management, and 5.3% were senior management (the remaining 1.1% identified their job as other).

Measures

Techno-Work Engagement Scale

We designed a new instrument—the TechnoWES-9—for measuring work engagement regarding the use of technology at work. The Finnish version of the Utrecht Work Engagement Scale (UWES-9; Hakanen, 2009; Schaufeli et al., 2006) was used as a starting point to build the new scale.

UWES captures the three dimensions of work engagement and is typically used to measure the level and factorial structure of work engagement. The shorter, nine-item version—UWES-9 (Schaufeli, Bakker and Salanova, 2006)—has become more popular than the 17-item version (UWES-17) and is now considered the standard (Kulikowski, 2017). Moreover, both versions of the UWES have been translated and validated for many different countries (Kulikowski, 2017). For example, in Finland, the UWES-9 is commonly used by scientists and practitioners (e.g., Hakanen, 2009). Recently, a three-item version (UWES-3) was introduced and was shown to be a reliable and valid alternative to measure work engagement (Schaufeli et al., 2017).

There are somewhat inconsistent findings concerning the factorial validity of the UWES, namely whether the theoretical three-factor structure—which includes the vigor, dedication, and absorption subscales—fits the empirical data better than other factor structures. The commonly established view is the fit of the three-factor structure is superior to the other models (e.g., Bakker et al., 2011). However, a recent review of 21 studies (Kulikowski, 2017) within the CFA approach assessed the factorial validity of the UWES-9 and UWES-17 and found no common agreement. Kulikowski (2017) assumed one reason for the inconsistent findings may be that work engagement is more context variant than universal.

In line with the UWES-9, the TechnoWES-9 consists of nine items that represent three subscales (i.e., vigor, dedication, and absorption), and each is measured by three items. Eight of the items were adopted from the UWES-9. We considered one of the UWES-9 items from the vigor subscale to be unsuitable in the context of techno-work engagement, namely 'When I get up in the morning, I feel like going to work,' and the item was excluded. To replace it, we adapted the item 'At my work, I always persevere, even when things do not go well' from the vigor subscale of the UWES-17. We considered this item both suitable and relevant because when using technology at work, people may face technological problems that demand perseverance. The selected items were then modified and rewritten (in Finnish) to fit a technology context. In practice, for example, the original item 'I am enthusiastic about my work' was modified to 'I am enthusiastic about utilizing technology in my job' (see **Table 1** for the English translations of all nine items). The original Finnish items are available from the first author upon request.

The respondents were asked to answer 'How often do you have the following kinds of feelings and thoughts' using a 7-point Likert scale ranging from 'never' (scored as 0) to 'always' (scored as 6) (c.f. Hakanen, 2009). At the beginning of the questionnaire, it was explained digital technology refers to electronic data transmission and the devices and applications that enable producing and utilizing knowledge, such as email, mobile phones, and social media. The respondents were not asked to think about any specific technology or application when answering the TechnoWES-9 items. The scale was part of the section that included questions about the respondents' work well-being and work conditions.

Table 1: Techno-Work Engagement Scale (TechnoWES).

No. from the original UWES-17	Dimension	Original UWES	Proposed Techno-Work Engagement Scale (TechnoWES)
VI1 ^a	Vigor	At my work, I feel that I am bursting with energy.	Techno_VI1. ^b When I utilize technology in my work, I feel that I am bursting with energy.
VI2 ^a	Vigor	At my job, I feel strong and vigorous.	Techno_VI2. I feel strong and vigorous when I use technology in my job.
VI6	Vigor	At my work I always persevere, even when things do not go well.	Techno_VI3. I always persevere with using technology in my work, even when it does not go well.
DE2 ^a	Dedication	I am enthusiastic about my job.	Techno_DE1. ^b I am enthusiastic about utilizing technology in my job.
DE3 ^a	Dedication	My job inspires me.	Techno_DE2. Utilizing technology inspires me in my job.
DE4 ^a	Dedication	I am proud of the work that I do.	Techno_DE3. I am proud that I utilize technology in my work.
AB3 ^a	Absorption	I feel happy when I am working intensely.	Techno_AB1. I feel happy when I am immersed in using technology in my work.
AB4 ^a	Absorption	I am immersed in my work.	Techno_AB2. ^b I am completely immersed in using technology in my work.
AB5 ^a	Absorption	I get carried away when I'm working.	Techno_AB3. I get carried away when I'm working with technology.

Note: VI = Vigor; DE = Dedication; AB = Absorption.

^a The item belongs to the UWES-9.

^b The item belongs to the TechnoWES-3.

Data analysis

We used LISREL 8.80 to perform CFAs to assess the fit of the hypothesized three-factor second-order structure (M1) and an alternative one-factor structure (M2) of the TechnoWES. We modeled the three-factor structure using a second-order model (Brunner, Nagy and Wilhelm, 2012) because the preliminary CFA analyses indicated high correlations (0.73–0.91, Sample 1; 0.82–0.87, Sample 2) between the three factors. In the three-factor second-order model, each factor (i.e., each subscale) was specified to include three items, and one item loading for each factor was constrained to 1 to determine the scale of the latent variables. On the second-order level, one factor loading was constrained to 1 (and error variance was constrained to 0.01) to achieve identification of the model. In the one-factor model, all the items were specified to load onto a single factor, with one item loading constrained to 1. Because of the non-normality of the data (mean skewness = -0.40, range from -0.70 to -0.03; mean kurtosis -0.89, range from -1.30 to -0.41, Sample 1; mean skewness = 0.09, range from -0.31 to 0.73, mean kurtosis = -1.07, range from -1.23 to -0.79, Sample 2), we used the diagonally weighted least squares (DWLS) estimation method. We used DWLS instead of robust ML because it has been shown to be less biased and more sensitive in the case of non-normal item distributions and in scales with five or more categories (e.g., Li, 2016).

The CFA models were evaluated with the chi-squared test and other fit indicators: root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), non-normed fit index (NNFI, or the Tucker–Lewis index; TLI), and comparative fit index

(CFI). The Akaike information criterion (AIC) was used to compare the models, with a smaller value indicating a better fit (Schreiber et al., 2006).

The acceptable model fit is indicated by a χ^2/df ratio of 3 or less (Schreiber et al., 2006). The widely used cut-off values for evaluating the fit of CFA models to the data come from Hu and Bentler's (1999) simulation study; they are 0.06 for RMSEA, 0.08 for SRMR, and 0.95 for CFI and TLI. However, some scholars have suggested these cutoffs may not be valid in all latent variable models and should therefore not be treated as universal golden rules or overgeneralized into all contexts (e.g., Marsh, Hau and Wen, 2004; McNeish, An and Hancock, 2018). More specifically, recent studies have shown measurement quality (i.e., the magnitude of the standardized factor loadings in the model) affects the size of the goodness-of-fit values, so models with high-quality measurement tend to yield worse goodness-of-fit values (leading to conclusions that the overall data–model fit is poor) than models with lower measurement quality—phenomenon referred to as the reliability paradox (Hancock and Mueller, 2011; for a review and simulation, see McNeish et al., 2018). McNeish and colleagues (2018) demonstrated that with poorer measurement quality, an RMSEA value of 0.06 can indicate a poor fit. On the other hand, they showed that when the measurement quality is very high (standardized factor loadings of around .90), an RMSEA value of 0.20 can indicate an acceptable fit. In the current study, we follow McNeish and colleagues' (2018) recommendation to report the standardized factor loadings along with the goodness-of-fit indices to contextualize and interpret the latter and thereby better assess the data–model fit.

Results

The χ^2 and the other goodness-of-fit indices of the CFA models are presented in the upper part of **Table 2**. The three-factor second-order model (M1 3F-9_1) demonstrated a better fit than the one-factor model (M2 1F-9_1), with $\chi^2 = 402.34$, $df = 25$, $p < 0.001$, RMSEA = 0.14, SRMR = 0.078, NNFI = 0.95, and CFI = 0.96. The results showed an acceptable fit according to the recommended cut-off criteria of Hu and Bentler (1999), except for the RMSEA, which exceeded the cut-off of .06. The χ^2/df ratio was 16.1, which exceeded the recommended (Schreiber et al., 2006) cut-off of 3.

The standardized factor loadings of the CFA models for the TechnoWES-9 are presented in **Table 3** (see the columns labeled Study 1). In the hypothesized three-factor second-order model, all factor loadings were ≥ 0.80 , except for the item adapted from the UWES-17, 'I always

persevere with using technology in my work, even when it does not go well' (abbreviated in the following as Techno_VI3), which was 0.49. Similarly, in the one-factor model, the loading of that item was the lowest at 0.47; whereas, all other loadings were ≥ 0.79 .

The factor reliabilities were calculated with the omega coefficient, which ranges from 0 (no reliability) to 1 (perfect reliability; Brunner et al., 2012; see the last row of **Table 3**).

The overall level of techno-work engagement ($M = 3.49$, $SD = 1.47$) did not differ statistically significantly between females ($M = 3.52$, $SD = 1.50$) and males ($M = 3.40$, $SD = 1.41$), $t(706) = -1.04$, $p = 0.299$, which was true for the three subscales. The overall level of techno-work engagement also did not differ between officials/experts ($M = 3.50$, $SD = 1.47$), workers ($M = 3.34$, $SD = 1.53$), supervisors/management ($M = 3.62$, $SD = 1.36$), senior

Table 2: Goodness-of-fit statistics for the alternative CFA models for the TechnoWES.

Sample	Models	$\chi^2(df)$	RMSEA [90% CI]	SRMR	NNFI	CFI	AIC	$\Delta\chi^2(\Delta df)$	<i>p</i>
Study 1									
(<i>n</i> = 729)	M1 3F-9_1	402.34 (25)	0.14 [0.13, 0.16]	0.078	0.95	0.96	442.34		
(<i>n</i> = 729)	M2 1F-9_1	737.61 (27)	0.19 [0.18, 0.20]	0.087	0.91	0.93	773.61	331.27 (2)	<0.001
Study 2									
(<i>n</i> = 213)	M1 3F-9_2	118.59 (25)	0.13 [0.11, 0.16]	0.069	0.96	0.97	158.59		
(<i>n</i> = 213)	M2 1F-9_2	278.58 (27)	0.21 [0.19, 0.23]	0.077	0.91	0.93	314.58	155.99 (2)	<0.001

Note: TechnoWES = Techno-Work Engagement Scale; M1 = hypothesized three-factor second-order model; M2 = alternative one-factor model.

Table 3: Standardized factor loadings of the CFA models for the TechnoWES.

	Study 1 (<i>n</i> = 729)				Study 2 (<i>n</i> = 213)					
	3-factor second-order model				1-factor model	3-factor second-order model				1-factor model
	VI	DE	AB	Total	Overall TechnoWES	VI	DE	AB	Total	Overall TechnoWES
Techno_VI1	0.95				0.92	0.95				0.93
Techno_VI2	0.97				0.93	0.97				0.94
Techno_VI3	0.49				0.47	0.66				0.61
Techno_DE1		0.86			0.82		0.86			0.81
Techno_DE2		0.86			0.82		0.91			0.85
Techno_DE3		0.84			0.82		0.83			0.79
Techno_AB1			0.84		0.82			0.89		0.86
Techno_AB2			0.80		0.79			0.89		0.87
Techno_AB3			0.84		0.82			0.93		0.91
Omega coefficient	0.82	0.88	0.87	0.95	0.94	0.88	0.89	0.93	0.96	0.96

Note: TechnoWES = Techno-Work Engagement Scale; VI = Techno_Vigor; DE = Techno_Dedication; AB = Techno_Absorption. For the complete items, see Table 1.

management ($M = 3.72$, $SD = 1.47$), and 'other' ($M = 2.54$, $SD = 1.69$), $F(4, 724) = 1.70$, $p = 0.148$. This was also the case for the TechnoWES_Vigor and TechnoWES_Absorption subscales. For the TechnoWES_Dedication subscale, the overall effect was statistically significant $F(4, 724) = 2.48$, $p = 0.043$, but the post hoc test (Scheffe) could not locate a difference. Age did not statistically significantly correlate with the overall level of technowork engagement ($r = -0.04$, $p = 0.287$) or with any of the three subscales.

Brief discussion

Using data from employees of eight different organizations, we found that the TechnoWES-9 worked reasonably well although one item turned out to be less than ideal. Study 1 provides support for the hypothesis that the three-factor structure of the TechnoWES fits the data better than the one-factor structure (Hypothesis 1). Study 2 tests whether this finding can be replicated in another dataset collected from teachers. Although the respondents in Study 1 were not asked to think about any specific technology when answering the TechnoWES items, in Study 2, the participants were instructed to think about educational technology. Therefore, Study 2 adds to Study 1 by testing the scale in a specific context of work-related technology use. Furthermore, Study 2 assessed the discriminant and convergent validity of the TechnoWES.

Study 2

Method

Participants and data collection

Originally, 216 teachers and principals from 15 Finnish schools answered a web-based questionnaire. All the procedures were executed following the ethical principles and code of conduct of the American Psychological Association. Informed consent was obtained from the participants. The response rate was 67%, which varied from 24–100% across the schools. Three principals reported they could not answer the TechnoWES because they did not currently use educational technology. Their responses were excluded from the current analyses, so the total number of respondents was 213, of whom 160 (75.1%) were female and 53 (24.9%) were male. The average age of the respondents was 44.5 ($SD = 9.3$, range 23–63) years. The average length of the work experience varied from 0 to 40 years, the average being 15.6 years ($SD = 8.9$). A total of 94 (44.1%) subject teachers, 110 (51.6%) classroom teachers, and 9 (4.2%) principals participated. Regarding the school level, 113 (53.1%) of the respondents taught mainly at primary school, 44 (20.7%) at lower secondary school, 11 (5.2%) at both primary and lower secondary school, 6 (2.8%) at both lower secondary and upper secondary school, and 37 (17.4%) at upper secondary school (2 responses were missing).

Measures

Techno-Work Engagement Scale

The TechnoWES-9 was used. However, there was one difference: in the introductory text preceding the scale, it was specified the word 'technology' refers to the educational technology the respondent utilizes in her or his job.

Therefore, the respondents were asked to think about educational technology in particular and were informed educational technology refers to the different forms of ICT used in teaching.

Technology-related job resources

To measure technology-related job resources, we adapted and modified the scales and items from previous studies, each of which was measured with three items: Technology-related autonomy (Cronbach's $\alpha = 0.67$; e.g., 'I use educational technology in teaching voluntarily'; Lam et al., 2010), technology-related social support ($\alpha = 0.86$; e.g., 'My colleagues support me if I encounter difficulties in using educational technology'; Lam et al., 2010), technology-related self-efficacy ($\alpha = 0.86$; e.g., 'I feel confident that I have the necessary skills in educational technology'; Wang et al., 2004), and technology-related value congruence ($\alpha = 0.82$; e.g., 'My values related to educational technology are in accordance with the values which are emphasized at this school'; Skaalvik and Skaalvik, 2011). For example, the original item 'My educational values are in accordance with the values which are emphasized at this school' was changed to 'My values related to educational technology are in accordance with the values which are emphasized at this school' (see the report by Mäkineniemi et al., 2017).

Technostress

To measure technostress, we used the 16-item technostress scale (Salanova et al., 2013) that was translated from Spanish to Finnish using a backtranslation procedure and modified to fit the context of educational technology. The CFA of the technostress scale supported the four-factor solution ($\chi^2 = 198.39$, $df = 98$, $p < 0.001$, CFI = 0.99, RMSEA = 0.07), which is in line with previous studies (e.g., Salanova et al., 2013). Each of the four dimensions was measured with four items: anxiety (e.g., 'I feel tense and anxious when I work with educational technology'), fatigue (e.g., 'It is difficult for me to relax after a day's work using educational technology'), skepticism (e.g., 'As time goes by, educational technology interest me less and less'), and inefficacy (e.g., 'In my opinion, I am inefficient when using educational technology'). The Cronbach's alpha for the overall technostress was 0.95, and it ranged from 0.83 to 0.92 for the subscales.

Data analysis

We used the same CFA analytic procedures as in Study 1 to assess the dimensionality and factor structure of the TechnoWES-9.

Further, following the procedures of Schaufeli and colleagues (2017), we examined the possibility technowork engagement could be measured with three items only because the UWES-3 can be used as an alternative to the UWES-9. The three items included in the analysis (TechnoWES-3) were as follows: 'When I utilize technology in my work, I feel that I am bursting with energy' (Techno_V11), 'I am enthusiastic about utilizing technology in my job' (Techno_DE1), and 'I am completely immersed in using technology in my work' (Techno_AB2).

First, we assumed both versions of the TechnoWES can be discriminated against from technostress. We tested this

assumption by conducting two sets of CFAs (using LISREL 8.80), that is, one for each version of the TechnoWES. In the first model, the null model (M0_dv), all items were specified to load on one latent factor; whereas, in the second model (M1_dv), each (sub)scale represented a separate latent factor (i.e., one TechnoWES factor and four technostress factors). The difference between the two models was tested using the $\Delta\chi^2$ statistic. Obtaining a significant difference would indicate the superiority of fit of the second model with separate factors (M1_dv) and hence that the TechnoWES can be discriminated from technostress.

Second, we analyzed the internal consistency of both versions with Cronbach's alphas. Third, we computed the correlation between both versions of the TechnoWES scale totals, the correlation of each single item with the total of the rest of the items for each version, and the correlations of the single items of the TechnoWES-3 with the total score of TechnoWES-9. Fourth, we analyzed the demographic factors (age, gender, teacher type) in relation to the TechnoWES-9 and TechnoWES-3, assuming similar relations would be observed for both. Fifth, we analyzed whether the correlations of both TechnoWES versions with technostress are similar. Sixth, we analyzed whether the correlations of both TechnoWES versions with technology-related job resources are similar. For the analyses in steps two to six, we used IBM SPSS Statistics 25.

Results

The χ^2 and the other goodness-of-fit indices of the CFA models are presented in the lower part of **Table 2**. The three-factor second-order model (M1 3F-9_2) demonstrated a better fit than the one-factor model (M2 1F-9_2), with $\chi^2 = 118.59$, $df = 25$, $p < 0.001$, RMSEA = 0.13, SRMR = 0.069, NNFI = 0.96, and CFI = 0.97. The results showed acceptable fit according to the recommended cut-off criteria of Hu and Bentler (1999), except for the RMSEA, which exceeded the cut-off of 0.06. The χ^2/df ratio was 4.7, exceeding the recommended cut-off of 3 (Schreiber et al., 2006).

The standardized factor loadings of the CFA models for the TechnoWES are presented in **Table 3** (see columns labeled Study 2). As in Study 1, all loadings were ≥ 0.83 in the three-factor second-order model and ≥ 0.79 in the one-factor model, except for the item 'Techno_VI3' (adapted from the UWES-17), which was 0.66 in the three-factor

second-order model and 0.61 in the one-factor model. The factor reliabilities are reported in the last row of **Table 3**.

The overall level of techno-work engagement ($M = 2.85$, $SD = 1.51$) did not differ significantly between female ($M = 2.80$, $SD = 1.48$) and male ($M = 3.00$, $SD = 1.60$) respondents, $t(211) = 0.84$, $p = .405$; also the means of the three subscales did not differ between females and males. The overall level of the TechnoWES varied between different types of teachers, $F(2, 210) = 6.24$, $p = 0.002$, with principals ($M = 4.48$, $SD = 1.36$) scoring significantly ($p < 0.01$) higher than classroom teachers ($M = 2.68$, $SD = 1.43$) and subject teachers ($M = 2.88$, $SD = 1.54$), as indicated by the post hoc Scheffe test. This was also the case for all three subscales, with principals scoring higher than classroom and subject teachers. Age did not statistically significantly correlate with the overall level of the TechnoWES ($r = -0.11$, $p = 0.111$) or with the subscales TechnoWES_Vigor ($r = -0.13$, $p = 0.063$) and TechnoWES_Absorption ($r = -0.04$, $p = 0.563$) but was negatively associated with TechnoWES_Dedication ($r = -0.14$, $p = 0.037$).

Discriminant validity

The results presented in **Table 4** indicate the null models (M0_dv) with one general well-being factor did not fit the data; whereas, the fit of the models with separate factors (M1_dv) was sufficient although not flawless. The fit of the M1_dv was superior to that of the M0_dv ($\Delta\chi^2 = 4315.66$; $df = 10$, $p < 0.001$ for the TechnoWES-9 and $\Delta\chi^2 = 682.01$, $df = 10$, $p < 0.001$ for the TechnoWES-3), indicating that both TechnoWES versions can be discriminated from technostress.

Internal consistency

The Cronbach's alphas for the TechnoWES-9 (0.94) and TechnoWES-3 (0.81) were sufficient.

Correlations between both versions

The correlation between the TechnoWES-9 and TechnoWES-3 was 0.96, indicating a shared variance of 92% between the versions. The correlation of each single item with the total of the rest of the items ranged from 0.62 to 0.71 for the TechnoWES-3 and from 0.58 to 0.84 for the TechnoWES-9. The correlations of the single items of the TechnoWES-3 with the total score of the TechnoWES-9 were 0.84 for Techno_VI1, 0.82 for Techno_DE1, and 0.81

Table 4: CFA fit indices for the models assessing discriminant validity of the TechnoWES from technostress (Study 2; $n = 213$).

Concepts	Models	$\chi^2(df)$	χ^2/df	RMSEA	SRMR	CFI	NFI	$\Delta\chi^2(\Delta df)$	p
TechnoWES-9 and technostress	M0_dv_9	4938.15 (275)	18.0	0.28	0.22	0.71	0.70		
	M1_dv_9	622.49 (265)	2.3	0.08	0.06	0.98	0.96	4315.66 (10)	<0.001
TechnoWES-3 and technostress	M0_dv_3	931.94 (152)	6.1	0.16	0.12	0.93	0.92		
	M1_dv_3	249.93 (142)	1.8	0.06	0.05	0.99	0.98	682.01 (10)	<0.001

Note: TechnoWES = Techno-Work Engagement Scale; M0 = the null model in which all items are specified to load on one general factor; M1 = the model with separate latent factors.

for Techno_AB2, indicating the items constituting the TechnoWES-3 represent well the pool of the TechnoWES-9 items.

Relations with demographic variables

The Pearson correlation of the TechnoWES-3 with age ($r = -0.10, p = 0.133$) was similar to that of the TechnoWES-9 (reported above). There were no gender differences in TechnoWES-3: $t(211) = 1.19, p = 0.234$, females ($M = 2.71, SD = 1.48$) and males ($M = 3.00, SD = 1.60$), which was also true for the TechnoWES-9. Regarding the teacher type, similar differences as those reported for the TechnoWES-9 were observed also for the TechnoWES-3, $F(2, 210) = 4.97, p = 0.008$, with principals ($M = 4.22, SD = 1.40$) scoring significantly ($p < 0.05$) higher than classroom teachers ($M = 2.62, SD = 1.43$) and subject teachers ($M = 2.84, SD = 1.55$), as indicated by the post hoc Scheffe tests.

Relations with technostress

Table 5 shows that all correlations of techno-work engagement with technostress were negative, as expected: overall technostress $r = -0.39/-0.37$, Technostress_Scepticism $r = -0.42/-0.43$, Technostress_Fatigue $r = -0.24/-0.22$, Technostress_Anxiety $r = -0.32/-0.29$, and Technostress_Inefficacy $r = -0.36/-0.34$, for the TechnoWES-3 and TechnoWES-9, respectively. Generally, the correlations were very similar, with an average difference of only 0.02.

Relations with technology-related job resources

As can be seen from **Table 5**, all correlations with technology-related job resources were positive: technology-related autonomy $r = 0.40/0.43$, technology-related social support $r = 0.22/0.23$, techno-efficacy $r = 0.46/0.47$, and technology-related value congruence $r = 0.36/0.38$, for the TechnoWES-3 and TechnoWES-9, respectively. Generally, the correlations were very similar, with an average difference of 0.02.

Brief discussion

We found the TechnoWES-9 worked reasonably well; although, again, one item turned out to be somewhat problematic. Study 2 provides further support for our hypothesis that the three-factor structure of the TechnoWES fits the data better than the one-factor structure (Hypothesis 1). Also, hypotheses 2–4 were supported. Both versions of the scale can be discriminated from the technostress scale, and there was a moderate negative correlation between techno-work engagement and technostress. The sizes of the correlations were very similar in both versions. There was a positive moderate correlation between techno-work engagement and all four technology-related job resources, which applies to both scale versions. The sizes of the correlations were very similar. As assumed, the TechnoWES-9 and TechnoWES-3 were highly correlated, with a shared variance of 92%. Finally, the relationships of the demographics with techno-work engagement were very similar for both the three-item and nine-item versions of the scale.

General discussion

The aim of the current study was to present a novel construct called techno-work engagement and to assess the factorial, divergent, and convergent validity of the new TechnoWES. There is a clear need for a new construct because there is a lack of scales focusing on the positive well-being experiences regarding technology at work. One exception is a scale assessing flow experiences in the context of ICT work (Rodríguez-Sánchez et al., 2008).

In line with the previous findings and established thinking on work engagement, we first hypothesized the three-factor structure of the TechnoWES-9 would fit the data better than the one-factor structure; the results of the two samples supported this hypothesis. The main finding indicates techno-work engagement can be defined as a second-order factor reflected in employees' technology-related

Table 5: Pearson's correlations of the TechnoWES with technostress and technology-related job resources (Study 2; $n = 213$).

	TechnoWES-9	TechnoWES-3	Techno_Vigor	Techno_Dedication	Techno_Absorption
Technostress	-0.37***	-0.39***	-0.34***	-0.39***	-0.29***
Technostress_Scepticism	-0.43***	-0.42***	-0.39***	-0.46***	-0.35***
Technostress_Fatigue	-0.22**	-0.24***	-0.20**	-0.25***	-0.16*
Technostress_Anxiety	-0.29***	-0.32***	-0.27***	-0.31***	-0.22**
Technostress_Inefficacy	-0.34***	-0.36***	-0.31***	-0.34***	-0.29***
Technology-related autonomy	0.43***	0.40***	0.38***	0.45***	0.36***
Technology-related social support	0.23***	0.22**	0.21**	0.22**	0.22**
Techno-efficacy	0.47***	0.46***	0.44***	0.41***	0.45***
Technology-related value congruence	0.38***	0.36***	0.33***	0.36***	0.36***

Note: TechnoWES = Techno-Work Engagement Scale.

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

vigor, dedication, and absorption. This supports Schaufeli and colleagues' (2002) original conceptualization work engagement is a three-dimensional construct. Moreover, similar findings can be found in work engagement studies (see, e.g., Sinval et al., 2018). Treating techno-work engagement as a second-order construct allows for the estimation of a single value (i.e., general score) for work engagement while retaining the three first-order factors (c.f. Sinval et al., 2018).

Our results indicated one of the vigor items—'I always persevere with using technology in my work, even when it does not go well'—had the lowest factor loadings. Interestingly, the original version of this item has also been problematic in prior studies (e.g., Seppälä et al., 2009). We suggest future studies consider including some other vigor items in the TechnoWES and test which of them works the best. Also, qualitative data could help develop the scale further. It is also worth noting the problematic item is not included in the TechnoWES-3.

Moreover, based on the χ^2/df ratio (4.7 for Study 2 and 16.1 for Study 1), the three-factor second-order model fit somewhat better to the dataset used in Study 2 when compared with the one used in Study 1. There are at least two possible reasons for this. First, the participants in Study 2 were more homogenous in terms of doing similar work, and second, the introduction text for the respondents differed. In Study 2, the respondents were asked to think about educational technology in particular; whereas, there were no such restrictions in Study 1. Here, the main aim of the current paper was not to compare the two samples but to develop and test two different ways of using the novel scale. We recommend in future studies, the TechnoWES be used as in Study 2, that is, using an introduction text to specify what technology the respondent should think about when answering. This may make answering easier for the respondents.

We also expected a three-item version of the TechnoWES is a valid measure and can be used as an alternative to the nine-item version. We found support for this assumption because the TechnoWES-9 and TechnoWES-3 share 92% of their variances and have high internal consistency. Furthermore, the pattern of correlations of both versions with technostress and technology-related job resources was highly similar. Also, both versions can be discriminated from the technostress scale. Finally, the demographic relationships were very similar for both versions.

Study 2 showed technology-related job resources were positively associated with techno-work engagement. The finding that factors associating positively with work engagement also associate positively with techno-work engagement may be taken as an indication techno-work engagement could be considered a type of work engagement. Future studies could examine this idea by including both the UWES and TechnoWES in their analyses, which would allow for an empirical study of their interrelationships. This could help in understanding more deeply the task-specificity of work engagement (c.f. Sonnentag, 2017).

Our results indicate technostress and techno-work engagement are divergent concepts and there appears to be a negative correlation between them. However, stress is a complex phenomenon involving a mixture of positive (i.e., eustress) and negative (i.e., distress) experiences (cf. O'Sullivan, 2010); more sophisticated methods are needed for a deeper exploration of their relationship. We believe established and large-scale technostress research traditions could benefit from integrating technostress and techno-work engagement scales in the same studies for getting a broader view of the negative and positive well-being experiences (c.f. Tarafdar et al., 2019).

Limitations and future directions

In line with previous findings on work engagement using the versions of the UWES (e.g., de Bruin and Henn, 2013; Kim, Park and Kwon, 2017; Wefald et al., 2012), the RMSEA values of the current study were not ideal according to the more traditional cut-off value of 0.06 (Hu and Bentler, 1999). However, as mentioned above, the measurement quality affects the size of the RMSEA, so larger factor loadings tend to yield larger RMSEA values (McNeish et al., 2018). Therefore, because the factor loadings of the TechnoWES items in the current study were large (all ≥ 0.80 and up to 0.97, except for the above-mentioned vigor item), the obtained RMSEA values (0.13–0.14) for the best-fitting model (i.e., the three-factor second-order model) are likely to indicate acceptable fit. Therefore, the three-factor structure was not flawless. However, the fit of the model was in line with previous studies on work engagement.

Although the current study supports the notion techno-work engagement and work engagement have a similar factorial structure, the relationship between them remains unclear. Also, the relationship between techno-work engagement and flow experiences in the context of ICT work (Rodríguez-Sánchez et al., 2008) is still unclear. These relationships could be further explored in future studies.

The other limitations of the present study are the inclusion of only Finnish employees and that the alternative three-item version of the scale could be analyzed only in Study 2 with a relatively small sample. A further limitation was the low response rate from some of the participating organizations in Study 1. One likely reason for this is the TechnoWES was measured within long questionnaires that contained many other scales as well, likely causing fatigue. Also, the phenomenon was potentially unfamiliar. It is worth noting that at the beginning of the questionnaire in Study 1 a broad definition of digital technology including various devices and applications was presented. So the respondents were not advised to think about a specific technology as in Study 2. This type of priming may have made answering challenging. It would be good to focus on one technology at a time in the future. Also, the use of the three-item scale can decrease potential response fatigue. Shorter, reliable scales have other benefits (Fisher, Matthews and Gibbons, 2016): for example, because of time constraints, employers may be more willing to include shorter scales in their employee surveys.

Although technology-related well-being does not seem to be a very sensitive topic, answering the TechnoWES may raise doubts. This may happen especially if employees feel forced to use novel technology and feel social pressure to be motivated and enthusiastic about it, even if they perceive the technology as difficult, pointless, or stressful. Therefore, it might be a good idea to measure both techno-work engagement and technostress experiences for getting a broad view and a chance for respondents to express negative feelings or experiences associated with the use of technology at work.

Prior studies indicated work engagement is associated with many positive outcomes, such as better performance and job commitment (see, e.g., Bakker and Demerouti, 2017). Based on the current study, it is not possible to know whether techno-work engagement also has a similar type of positive effect. Indeed, there are many negative aspects related to the use of technology. For example, constant interruptions seem to increase stress levels, and the constant availability of employees through technology decreases their recovery and good work-life balance. Therefore, it is important to explore not only the positive, but also negative, effects of techno-work engagement. In addition, we suggest longitudinal studies be performed to study the stability of techno-work engagement, and techno-work engagement should be studied in different contexts and occupations and associated with the use of different technologies. The face validity of the current scale could also be analyzed and evaluated more deeply.

Although the factor structure of the TechnoWES-9 was not flawless, it worked reasonably well in the two samples. Also, the TechnoWES-3 can be used as an alternative to the TechnoWES-9.

Appendix

Supplementary Table 1: Correlations among the TechnoWES items and subscales in Studies 1 and 2.

	Study 1 (n = 729)		Study 2 (n = 213)		1.	2.	3.	4.	5.	6.	7.	8.	9.
	M	SD	M	SD									
1. Techno_VI1	3.57	1.87	2.82	1.84	–	0.93	0.32	0.75	0.75	0.66	0.67	0.53	0.60
2. Techno_VI2	3.55	1.90	2.87	1.85	0.94	–	0.33	0.78	0.77	0.69	0.66	0.52	0.58
3. Techno_VI3	3.89	1.77	3.29	1.95	0.42	0.43	–	0.42	0.37	0.44	0.45	0.42	0.40
4. Techno_DE1	4.22	1.59	3.87	1.67	0.70	0.72	0.59	–	0.82	0.71	0.66	0.52	0.58
5. Techno_DE2	3.81	1.74	3.46	1.75	0.73	0.76	0.59	0.85	–	0.71	0.72	0.52	0.61
6. Techno_DE3	3.69	1.87	3.15	1.84	0.66	0.71	0.50	0.62	0.70	–	0.74	0.62	0.67
7. Techno_AB1	3.01	1.88	2.59	1.92	0.75	0.76	0.51	0.68	0.75	0.75	–	0.68	0.72
8. Techno_AB2	2.85	1.99	1.66	1.79	0.65	0.64	0.51	0.62	0.64	0.69	0.77	–	0.85
9. Techno_AB3	2.80	1.98	1.90	1.85	0.70	0.68	0.59	0.69	0.73	0.68	0.81	0.90	–
Techno_Vigor (VI)	3.67	1.53	2.99	1.59									
Techno_Dedication (DE)	3.90	1.57	3.50	1.57									
Techno_Absorption (AB)	2.89	1.76	2.05	1.71									

Note: TechnoWES = Techno-Work Engagement Scale. The correlations of Study 1 are reported above the diagonal and correlations of Study 2 below the diagonal. For the complete items, see Table 1.

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Competing Interests

The authors have no competing interests to declare.

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